Derivation of Protective Nutrient Concentration Thresholds for the FKNMS Waters

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INTRODUCTION

The State of Florida and EPA are in the process of developing numerical nutrient criteria for estuaries and marine waters of Florida. Our objective is to provide a scientifically defensible methodology to assist the Florida Department of Environmental Protection (FDEP) and the U.S. Environmental Protection Agency (EPA) in developing numeric nutrient criteria for South Florida (SoFlo) estuaries and coastal waters. Given SoFlo's diverse geomorphologic, climatic, circulation and ecosystem structure coupled with differential human intervention and management, these numeric nutrient criteria should be developed at the sub-basin levels. Although SoFlo water quality (WQ) monitoring has been in place for over 18 years, quantitative studies relating nutrient enrichment to shifts in ecosystem components structure and/or health are lacking. Hence, the primary variables of concern in criteria development, total phosphorus (TP) and total nitrogen (TN) as causal enrichment variables will be connected here to chlorophyll-*a* (CHLa) as response variable, aiming to facilitate an understanding of cause-and-effect relationships in these complex systems. Then we will quantify nutrient levels (thresholds) for TN and TP, above which significant phytoplankton biomass (CHLa) shifts would occur. These would be the protective nutrient thresholds

SEGMENTATION METHOD

Combination of Principal Component Analysis (PCA) and Hierarchical Clustering methods in tandem:

-Biogeochemical variables were selected for PCA

- Mean, standard deviation, median and median absolute deviation of retained station scores were input to Hierarchical clustering routines, accounting for level of individual variables and their variability.

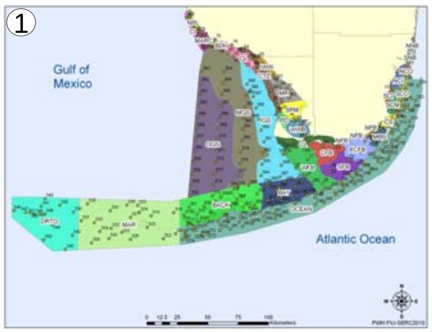


Figure 1. Subdivision of SoFlo waters into 37 biogeochemically homogeneous segments.

Z-SCORED CUMULATIVE SUM APPROACH

Most ecological time-series are not normally distributed, are serially correlated, have variable mean and variance, contain gaps, statistical outliers and potential regime shifts, and display incomplete cycles of diverse amplitude and wavelength. Hence direct application of orthodox statistical methods for trend analysis without significant data modification is unviable. We explored the structure of time-series to identify and characterize their components (trend, cycles and noise) and to detect important breaks with cumulative sum charts, meaning, a plot of the running sum of standardized deviations from the time-series mean.

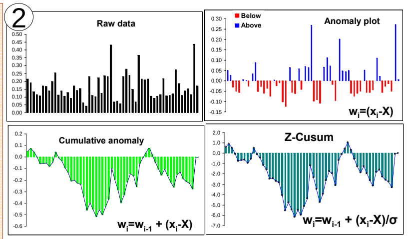
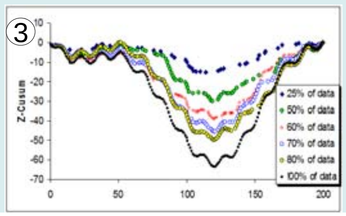


Fig 2. Comparison of time-series plotting methods

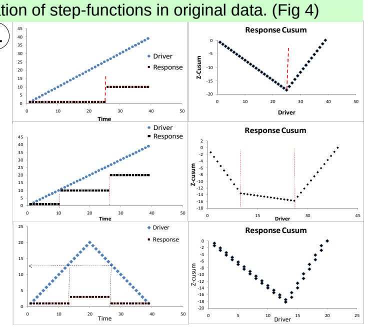
PROPERTIES OF Z-CUSUM

-Positive slopes in the line graph represent periods of above-average values and negative slopes indicate below-average values.

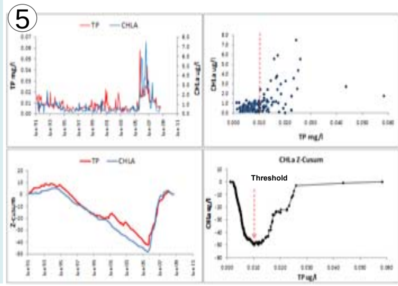
- Z-cusum data are resilient to data gaps. Fig 3 shows Z-cusum charts of progressive random "hole-punching" in a time-series, compared with the original data set (100%). General pattern and location of breaks is preserved even for only 50% of data



-Important slope breaks in Z-cusum data highlight the location of step-functions in original data. (Fig 4)



There is an expedite connection between driver and indicator response in Z-cusm rendition. Example in Fig 5 is from Manatee-Barnes Basin. CHLa values above 0.01 mg/l TP (threshold) are above CHLa average for the Period of Record.



DERIVATION OF TP AND TN THRESHOLDS FOR THE FLORIDA KEYS

We approached the derivation of nitrogen (TN) and phosphorus (TP) concentration thresholds for each segment by identifying TN and TP inflexion points (thresholds) above which significant increases in CHL-a would occur. As shown in Fig 6. these thresholds are directly read from the charts and were later validated with change-point analyzer software and/or Mann-Whitney tests.

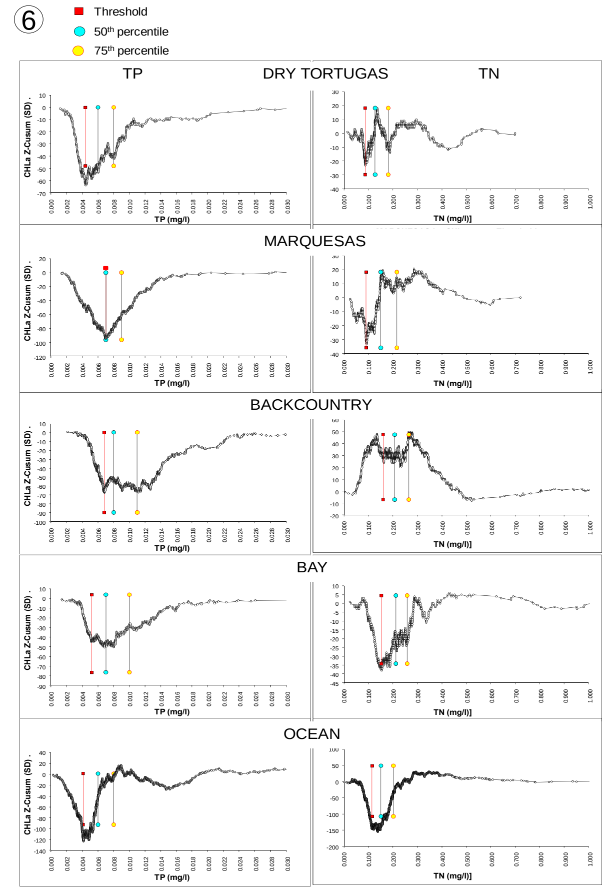


Figure 6. CHL-a Z-Cusum charts plotted along TP and TN gradients.

CONCLUSIONS:

Given the lack of quantitative studies relating nutrient enrichment to shifts in ecosystem components, Boyer et al (2009) proposed CHLa as ecological indicator for SoFlo estuaries and coastal waters. Our research moved a step further to derive protective nutrient levels for the FKNMS waters using CHLa Z-Cusum charts. The relevance of these threshold values is that they represent the nutrient level that if surpassed will drive the system to higher than average phytoplankton biomass generation. They might be selected as the long-term nutrient criteria if the water body complies with it designated use, and as the reference level for additional calculations of magnitude of upper bound limit (UP-L) to account for temporal variability (duration and frequency).

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